

A PRELIMINARY ACCOUNT
OF
THE BITING FLIES OF INDIA.

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PREFACE.

THE part played by blood-sucking insects in the transmission of diseases from man to man, or from animal to animal, is now well established in many instances, and it is impossible to say at present when investigation shall have reached the limit of these cases; every biting insect is therefore a possible factor in the dissemination of disease, and one of the first steps in this inquiry is to ascertain what are the insects that suck blood and where they occur, as well as to minutely investigate their life-histories, their habits, and the precise circumstances under which they live and multiply. One of the most important class of insects of this kind are the tse-tse flies of Africa; though at present known only in tropical Africa, they, or equally important flies, might readily occur in India. There is also the very unpleasant possibility that the sleeping sickness of Africa might be introduced in the blood of returning emigrants, and that some one of our Indian biting insects might prove capable of transmitting this disease from man to man. The study of biting insects is, therefore, so necessary a preliminary to further study from the medical and sanitary aspect, that, at the instance of the Sanitary Commissioner with the Government of India, and the Inspector-General, Civil Veterinary Department, an inquiry into blood-sucking flies was commenced; the Director of the British Museum (Natural History) has also urged upon the Government of India the necessity of this inquiry, and steps have been taken to secure the co-operation of officers of the Medical, Sanitary, and Civil Veterinary Departments in India. The initial difficulty has been to recognise and determine what are the biting

flies. Flies are a peculiarly difficult group, since their recognition depends upon minute characters requiring elaborate and careful study. They are the least known of all insects, and the abundant Indian forms have not attracted the attention of collectors and naturalists; there is very little recorded information on Indian flies. The impetus given to the study of mosquitoes by the discovery of the part played by them in the transmission of malaria, yellow fever, filariasis and kindred diseases has resulted in the collection and description of many Indian species; but this investigation was practically limited to this group, and though occasional other biting flies were described, no real attempt had been made to investigate the biting flies of this country.

With a view to facilitate the recognition and study of these insects, the following imperfect account of the progress made up to the present is here set forth; my aim has been to describe the results of the inquiry in a simple manner, giving only such technical details as are necessary for the discrimination of the flies that have been found to suck blood. I have had a very insufficient amount of time to devote to the work, nor have I the minute knowledge of flies that would enable me to properly deal with this inquiry; but I think the results obtained are of sufficient value to be a guide to others, and the distinct progress made enables us to give more assistance to observers who will interest themselves in this work.

The observations recorded here are primarily the work of Purushottam G. Patel, a special assistant on the staff of the Research Institute. I have directed and supervised the work, I have worked over all the specimens, and my share is limited to this and to the work of putting his observations, and my own, into this shape.

This work will shortly be taken over by Mr. F. M. Howlett, who has been appointed Second Imperial Entomologist; he will be in a position to devote a greater amount of time to it, and his knowledge of *Diptera* better qualifies him to carry on this investigation. The following pages were revised by him, but so many additions have been made since the manuscript was returned that any errors in it must be imputed to me.

I hope this short account will be of interest to the many officers in India who are in a position to observe and collect blood-sucking flies; Mr. Howlett will cordially welcome co-operation and will be able to give material assistance to any investigator. The subject is not only an important one but deeply interesting in itself, and it would be hard to find a subject better adapted for the spare hours of an observer in any part of India.

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I. INTRODUCTION.

THE blood of domestic animals and of man is the food of some of the following groups of insects in India:—

Anoplura. Lice.

Pulicidae. Fleas.

Diptera. Flies.

Cimicidae. Bugs.

There are also the ticks, which are not insects.

This bulletin deals with the flies, members of the order *Diptera*, distinguished from other insects by having one pair of wings, a pair of small knobs or halteres, and sucking mouth-parts. They are clearly distinct from practically all other insects by these characters, and are generally familiar in the common houseflies.

As specimens are required of all insects, etc., sucking the blood of animals, a few words may be said about the other groups.

***Anoplura.* Lice.**

These are wingless, flattened insects, with a distinct head, with three pairs of short legs, and with the suctorial proboscis of peculiar form.

Figure 1 depicts a typical form as an example of the group. They are likely to be confused with the very closely similar *Mallophaga* or biting lice, found also on mammals and birds, in which the blood-sucking habit is not known, but which are believed to live on hairs, fragments of skin and similar débris.

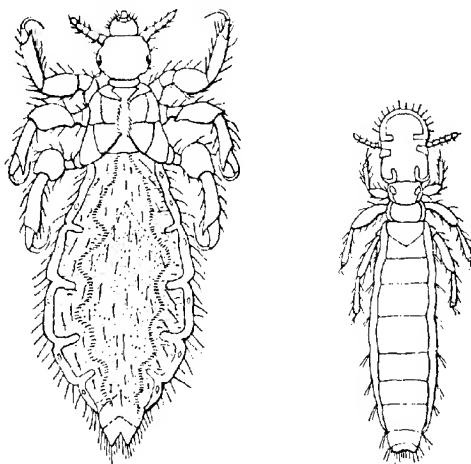


FIG. 1.
Pediculus capitis. *Head Louse.*

FIG. 2.
Lipeurus variabilis. *Fowl-biting Louse.*

The former are distinguishable most readily by their small head and by the three segments behind the head (the thorax) forming one mass. In the latter the head is larger, the first segment of the thorax distinct from the next two, which are closely attached to the abdomen. (Vide fig. 2.)

Specimens of both kinds of lice have been sent in from a variety of animals and man: more are wanted. They should be preserved in spirit or in formalin solution (3 per cent.).

Pulicidæ. Fleas.

Small laterally compressed wingless insects, with great power of

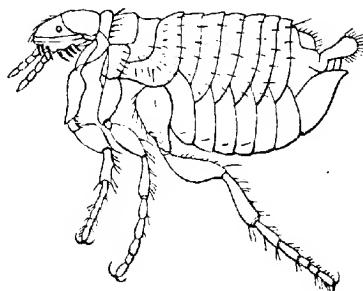


FIG. 3.
Pulex serraticeps. Dog and Cat Flea.

leaping, the head with suctorial mouth-parts. They are peculiar and are easily recognised by their form, and by being compressed from side to side, and not from above downwards. The papers of Captain Liston must be consulted for details of this group (see page 253 of the Journal of the Bombay Natural History Society, Volume XVI, No. 2, for description of fleas under the heading of "Plague, Rats, and Fleas").

Cimicidæ. Bugs.

Flattened insects of oval form, wingless, and running actively. The head is provided with a suctorial beak, which lies between the legs. They are dark-brown in colour, distinct from the above by their form. Two doubtfully distinct species are recorded from India. *Cimex lectularius* Linn., the European bed bug, and *Cimex macrocephalus* Dist. Specimens of bugs are required from all parts of India. The

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distribution in India of the two species is incompletely known, and every specimen sent in with the locality recorded will help in determining this

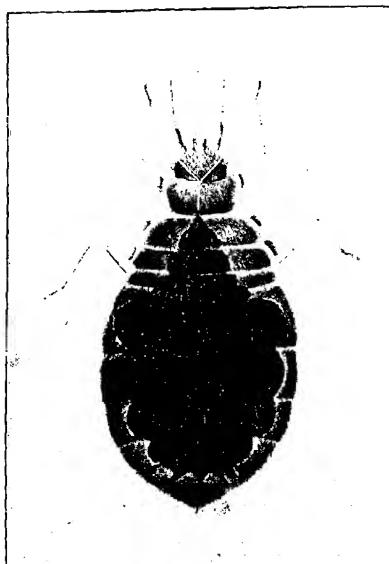


FIG. 4.
The Indian Bed Bug.

point. They should be preserved in spirit or in formalin solution (3 per cent.).

II. DIPTERA.

General Characters of Families.

Of the families of Flies in India, species which suck blood have been found in seven. Of these the species of one, *Hippoboscidae*, are so far known to bite animals only; while the individuals of a part of another (*Tabanidae*) far less often bite man than animals, so that they are unlikely to be of importance, save as carriers of disease from one animal to another.

So far as man is concerned, there are six families in which biting flies are known to occur, and whose importance may be immensely increased when more is known as to the diseases they are capable of transmitting. The same applies to the species which bite domestic animals, and we have included all the flies known to suck the blood of warm-blooded animals in India in this account. The families concerned are as follows:—

Scientific name.	English name.	Vernacular name.
I. <i>Chironomidae</i> .	Gnats . . .	Mugatara.
II. <i>Culicidae</i> .	Midges . . .	Busordi.
III. <i>Psychodidae</i> .	(In the plains) Sand-flies.	
IV. <i>Simuliidae</i> .	Mosquitoes . . .	Machhar.
V. <i>Tabanidae</i> .	Sand-flies . . .	
VI. <i>Muscidae</i> .	Horse-flies . . .	Dans.
VII. <i>Hippoboscidae</i> .	Gad-flies . . .	
	Flies . . .	Makhi.
	Forest-flies . . .	Kuku makhi.
	Horse-flies . . .	Bagai.
	Dog-flies . . .	Gomakhi.

The accurate identification of these families depends upon two characters principally, *viz.*, the venation of the wings and the form of the antennæ and mouth-parts. In utilising these characters it must be remembered that, while we know only a few species of biting flies, the actual identification of every species of biting fly is not possible; flies having the characters of the insects described here may be captured, but unless there is satisfactory evidence of its blood-sucking habit, it cannot therefore be written down as a blood-sucking fly. If a blood-sucking fly is obtained that has not these characters, it will be of great interest. The characters of these families may be stated in two ways.

In the first place, characters that are likely to be noticed by observers not acquainted with the technical terms and structural characters employed in Entomology. Secondly, the actual structural characters employed in the accurate separation of these insects by Entomologists. We discuss them separately.

(a) *Chironomidae*.—Small slender flies, not unlike small mosquitoes, which bite principally at night, are so small that they get through the mosquito-net and are usually observed only by their effects, and are not themselves seen. When captured whole, they are very small, green or black in colour, and inflated with blood. (See Plate I.)

Culicidae.—The mosquitoes are larger as a rule, are not capable of passing through a sound mosquito-net, but can bite through thin or porous clothes. They are found in cupboards and shady places in the house by day, emerge at dusk to sing and suck blood. They are grey, brown or black in colour, or banded with white, and the proboscis is usually discernible. (Fig. 7, page 11.)

Psychodidae.—Small flies with broad hairy wings; they look like very tiny moths, and are found on walls in bathrooms or where any water drips. (See Plate II.)

Simuliidae.—They are not, so far as we know, found in the plains, but occur in the Himalayas at 10,000 feet, and at lower elevations in Assam.

The bite of one is described as painful. They are generally very small in size, with stout but short legs; the wings are broad but delicate; generally the flies are black, with heads bent downwards. (Fig. 8.)

Tabanidae.—Large or very large flies of robust build found most commonly in the rains (or in hot weather) in forest localities, and also in towns. The head is flat and convex, largely consisting of eyes, usually beautifully coloured in the living insects. The beak is fleshy, pointed and short in the plains species, but in some of the hill species unusually long. They are typical flies and bite by day only. The wings in some are banded, in others grey mottled with white. Their flight is swift. They are very agile when about to bite; they settle quickly and insert their horny beak immediately into the flesh of their victims. The bite is felt as soon as the fly alights. [I can speak only of English *Tabanidae*, but (1) *T. bovinus* always has a considerable interval for meditation before biting; (2) the bite of *Chrysops* is not felt

(by me) as soon as begun, but as an unpleasant "drawing" sensation a little time afterwards.—F. M. Howlett.] (Plates III & IV.)

Muscidæ.—The biting species to the ordinary eye are like houseflies. Many are of the same size as the house-flies: others are smaller, a few bigger; but they are distinctly smaller than the *Tabanids*. The proboscis of the biting species is hard, needle-like, but never retractile as in the case of non-biting flies. Their bodies are moderately robust: legs shorter than those of mosquitoes: wings clear with shining reflections, and never banded or coloured. They fly by day, and the bite with the sharp beak is immediately felt. (Plates III & IV.)

Hippoboscidæ.—Flat and hard-bodied flies, which are common on dogs, cattle, and horses. They are usually greyish-brown or brown with yellow mottlings, and their wings are clear: the flight may be quick, and the flies, which are active by day, are most readily obtained on animals in their hair. They are common on birds also, and none of them bite man. (Plate IV.)

Scientific Characters.

Chironomidæ.—Small or minute flies, with antennæ slender, the joints distinct, the male usually with plumed antennæ. Legs and body slender. Proboscis usually short. Ocelli wanting, costal vein not passing beyond the tip of the wing. (Plate I.)

Culicidæ.—Antennæ slender, and the joints distinct, densely plumose in the males. Proboscis long. Costal vein extending round the whole margin of the wing; hind margin of the wing fringed with scale-like hairs. (Fig. 6.)

Psychodidæ.—Small flies, with thick hairy antennæ, with broad wings clothed in hair. (Plate II.)

Simuliidæ.—Antennæ short, bare, joints broadly united and not distinct. Proboscis not projecting. Body thick-set, legs stout. Wings destitute of hairs. The anterior veins fully developed, posterior weak.

Tabanidæ.—Antennæ composed of two basal joints and a number forming an apparent third joint. Squamae large. Venation distinct and complex, third longitudinal vein forked. Five posterior cells present, costal vein entirely surrounding the wing.

Muscidæ.—Antennæ composed of three joints and a dorsal arista, the latter plumose to the tip. Abdominal segments with bristles only towards the apex. Venation as in fig. 22.

Hippoboscidae.—Flattened flies, with small heads, without palpi, with the antennæ hidden; body bristly, legs short: usually winged species; found only on warm-blooded animals. The venation as in fig. 30.

III. CHIRONOMIDÆ.

These flies are common and abundant in India, almost all being harmless and not blood-sucking. The blood-sucking insects known in India under the term "sand-flies," however, include at least one species that belongs to this family; apparently this is one of several undescribed species of *Ceratopogon*; the common one is a small, rather thick-set fly, with greyish wings with large white spots. (Plate I, figs. 5, 6, 7.)

It is impossible to recognise the fly by any superficial character;



FIG. 5.
Wing of *Ceratopogon A.*

if a biting fly is captured having antennæ and wings as in fig. 5, and if it is very much smaller than a mosquito, a species of *Ceratopogon* has probably been secured.

Habits.—The fly comes out in the evening when the mosquitoes do, and bites freely; it is active apparently all night, and in the morning hides in a shady spot to spend the day. (As stated below, a small number were captured in the mosquito trap.) The female alone bites, the male probably living on plant sap; the bite is painful to most persons and raises spots on the skin. As the fly is small enough to get through a mosquito-net, it can prove a serious trouble, especially to small children. The flies are less common indoors than in the open; they hover in swarms in the still evening air, and then, descending, settle on cattle, get into the hair and suck blood. Purushottam remarks on the bite: "I have experienced many bites from these flies

and on many occasions it has been noticed that three thrusts are made by each fly. When settling on its victims it inserts its proboscis, which causes a smart, burning sensation, which after a while diminishes; a further burning sensation is then felt, which may be due to deeper thrust or to the injection of salivary fluid; this also dies away only to be followed by another smart sensation, after which the fly stops feeding."

The fly is practically noiseless in flight, but a dull humming is heard when a number are hovering in a swarm together. The males hover near the females when they feed, and immediately after go off with them to mate. This takes place in the evening. Horses and cattle are bitten, as well as fowls and ducks; human beings are most liable to be bitten when sleeping in the open or in a verandah: the flies also come into houses, and are fairly plentiful there in badly-infested localities.

It is at present uncertain how many species are concerned, as the discrimination of species is not easy; the species here referred to is common in Bengal and Behar; it was captured also by Major Stevens, I.M.S., in Arrah. Probably the same species occurs throughout India, and authentic specimens of the sand-fly of any place will be very welcome.

Life-history.—The small size of the fly, the absence of any records as to the life-history of such flies in India, and the variety of form and habitat of *Dipterous* larvae made the search for the larva of this fly a difficult one. Purushottam was engaged on it for some weeks, during which a number of possible larvae were reared, including the aquatic species, without success. Finally, larvae were found in the soil at the foot of a platform on which pots, dishes, etc., were washed, which proved to be those of this fly.

Larvæ when young are found in colonies of up to thirty; each larva is white, about $\frac{1}{50}$ inch long; they are found feeding in the decomposing vegetable matter on soil, not penetrating into the soil but feeding in the decaying matter that is soaked with water. Purushottam found the larval life to occupy thirteen days, the full grown larva being $\frac{1}{6}$ inch long.

The larva is elongate, tapering to head and tail (Plate I, fig. 1), sordid white in colour. The head and body are sparsely set with strong spines, with a spear-shaped head; the mouth-parts are complex and function as organs to sweep in small particles in the water. Behind the head is a single foot, with transverse ridges formed of lines of very small hooks. At the hind end is a long tapering dorsal process, shortly ciliated at the base (Plate I, fig. 2); below are four retractile gills of

the usual form; below there is a semicircular ridge set with two rows of curved spines; the anus is between the four gills and the ventral hooks.

Apparently this arrangement of gills and dorsal process enables the larva to keep the gills pressed against a damp surface and in the film of water found, for instance, on a damp stone or between damp leaves; no functional spiracles have been seen.

Pupa.—The pupa is figured on Plate I, fig. 3. The thorax is provided with respiratory trumpets of the forms shown (fig. 4), with a crenulated margin on one face. These trumpets serve to obtain air, the pupa hanging by them at the surface of the water when necessary.

The apex of the abdomen bears two hooks, which aid in locomotion. Pupation lasts four days.

Prevention.—There is probably no practical method of checking this fly, since it breeds in any decaying vegetation that is moist enough, and, in wet weather, there must be an ample supply of this material. Cleanliness in dry weather, especially with regard to kitchen water and similar material, is important, and where soil is saturated with dirty water the fly may be expected to breed and multiply.

IV. CULICIDÆ.

Slenderly built creatures, characterised by the long projecting proboscis. Antennæ in some cases very long, in others short but densely hairy; in male feather-like. Head small, eyes oval and reniform. Thorax convex and arched above without transverse suture on the dorsal disc. Abdomen long and narrow, generally composed of eight segments. Legs long but slender. Wings long and narrow, while at rest kept flat over

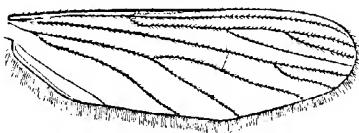


FIG. 6.
Wing of *Culex*; below, the scales on the margin magnified

the abdomen. The venation is generally without false veins, and the wings are fringed only on the lower margin by scales in form of hairs.

Mosquitoes are well known, and the student will find a mass of literature dealing with them. The part they play in the dissemination of certain diseases has been worked out, but it is not certain how far this is likely to be extended. No new work has been done in this group during this inquiry, and the literature should be consulted. The most recent list (Theobald in *Genera Insectorum*, 1905) enumerates 61 species of Indian *Culicidae*.

We may add certain practical suggestions for persons who suffer from mosquito bites in India. The radical cure of ordinary mosquitoes of course is to remove all their breeding-places. In India, the troublesome mosquitoes (not the malarial) in most stations in the plains are species which breed in small pools or in a very small quantity of stagnant water in which is a sufficiency of decaying organic matter. The liquid manure that the *mali* manufactures for chrysanthemums breeds mosquitoes plentifully, as does any dirty water near the kitchen. Cleanliness (good surface and bath water drainage) and a little care in preventing standing water is the surest method.

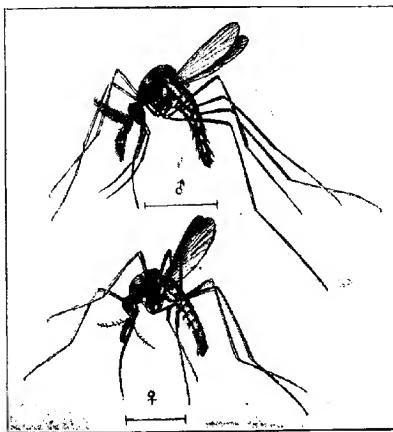


FIG. 7.
Male and Female of *Culex fatigans*.

Very often this is not possible; in this case one has to protect oneself against the bites of mosquitoes in the house. I find that Citronelle oil is a protection if I have to go to a specially bad place or if I have to sleep without a mosquito-net, as in trains for instance. A little of the oil poured on the palm of the hand and then rubbed round the face and neck and the feet is, for me, a sufficient protection; the oil has a pleasant and not wearying smell which does not remain next day. When overtaken by voracious mosquitoes in Assam, without the oil or a net, I found that the lemon grass from which the oil is made was a sufficient protection at night if a bunch was put near my head and my feet. The oil can be bought pure from chemists, and a few drops are sufficient at a time. I believe this is a better remedy than any of the "mosquito lotions" made for sale by chemists.

In the next place it is required to eliminate mosquitoes from a bungalow. In India, our common mosquitoes come in at sunrise and seek shady spots to sleep in. They then arise refreshed at sunset, they have an orchestral dance in the dusk, and go forth to seek food; some of the females remain to suck blood. Where it is possible to entirely close the house for an hour at sunrise, the mosquitoes cannot come in after their night out and their numbers in the house will be immensely reduced. It is possible to chase all the mosquitoes out by burning pyrethrum powder, but this cannot be done every day and is useful only in cases of necessity. The same applies to burning incense; if it is really necessary to get mosquitoes out for a few days say, buy pyrethrum powder and put a spoonful on hot coals in the room at dusk; the fumes will not kill the mosquitoes, but the latter will go out if an open window is available.

We describe one other method for what it is worth. It is obvious that mosquitoes like a cool shady place to sleep in and that is why they come into bungalows. As a rule, they find such a place in an almirah or a bookshelf. Owing to building operations which necessitate many brick-soaking pits and pools of water mosquitoes in Pusa have been very bad, as have the sand-flies. Experiments were made with a mosquito trap; a wooden box with a hinged door was used, lined with dark green baize. The box is 12 inches high, 12 inches broad, and 9 inches deep; a small hole covered by a revolving piece of wood or metal is necessary at the top, and there should be tin on the floor inside. This trap is put open in the most mosquito-haunted place and all the

mosquito haunts in that place are as far as possible closed or rendered uninhabitable; my room being open to the verandah, hordes of mosquitoes come in, and as the room is lined with bookshelves there are many desirable sleeping places. The trap stands in a shady corner, and a large number of mosquitoes enter it when they come home in the morning; the rest are usually driven out of the bookshelves either with a duster or a little tobacco smoke. Finding this desirable sleeping place untouched they go in; the door is then slammed and fastened. At the top of the box is a small hole with a movable plate to close it; through this a teaspoonful or less of benzene is introduced and the plate put back. After a little time all the mosquitoes are dead. The box is taken to the verandah and opened there till the fumes of benzene escape.

I give below the catch of each day for four weeks:—

DATE.	Mosquitoes, <i>Culex</i> <i>fatigans</i> Wied.	Sand-flies, <i>Ceratopogon</i> .	Males.	Females.
April 8th	43	...	...	...
" 9th	45	8	...	..
" 10th	32	2	...	...
" 11th	48	3	..	...
" 12th	30	3	...	...
" 13th	40	...	...	..
" 13th	7	2	..	...
" 14th	87	...	...	...
" 14th	24	...	...	...
" 15th	111	1	...	...
" 16th	81	...	...	...
" 17th	53	...	...	...
" 18th	110	...	...	...

DATE.	Mosquitoes, <i>Culex fatigans</i> Wied.	Sand-flies, <i>Ceratopogon.</i>	Males.	Females.
April 19th	60	...	...	...
,, 20th	61	...	...	...
,, 21st	63	...	...	...
,, 22nd	88	...	...	...
,, 23rd	133	...	...	...
,, 24th	124	...	...	...
,, 25th	203	...	...	...
,, 26th	70	...	..	...
,, 27th	197	...	...	...
,, 28th	59	...	37	22
,, 29th	41	3	...	...
,, 30th	68	...	53	15
May 1st	35	...	26	9
,, 2nd	102	...	79	23
,, 3rd	...	...	...	...
,, 4th	187	...	142	45
,, 5th	96	...	65	31
,, 6th	108	1	76	32
TOTAL	2,336	23	478	177

Daily average of both sexes 843
 " " females 2268
 Percentage of males 73
 " " females 27

I may remark that whereas the inmates were before pestered with mosquitoes and sand-flies which especially attacked the baby, this has now ceased; all the mosquitoes are not exterminated, but so large a

proportion are destroyed that practically we suffer no more. The mosquitoes are of course breeding outside and near other houses, and will continue to come in; but, in this case, the employment of the trap and a little benzene saved a great deal of annoyance.

I am not prepared to recommend this as a universal remedy. It must be sensibly used; a small amount of personal effort in teaching a servant is necessary at first. But where mosquitoes are a plague, especially to little children, the housekeeper's thirst for the blood of the mosquito may rise to so great a pitch that she will welcome this device and take a delight (as we do) in counting the corpses daily.

V. PSYCHODIDÆ.

Since the greater part of this bulletin was prepared and while it was under revision by Mr. Howlett in England, the discovery of a biting *Psychodid* in Pusa was made. This fly has been reared and has been found on occasion to bite greedily.

It is often stated that the sand-fly of India is a *Psychodid*; as far as my experience has gone, the most common sand-fly in Behar and Bengal is the *Ceratopogon* described above; the species here discussed (*Phlebotomus* sp.) is so far as at present known less abundant and bites less often. Purushottam has found these flies to remain motionless in the house during the day, usually in a dark spot and low down near the floor. He says that they are slow in flight without any audible hum, and they do not approach human beings so long as they are active. The females bite at night when their victim is asleep. They pass readily through a mosquito-net and become so gorged with blood that the abdomen is bright red and much distended. In captivity females lived about a week.

The principal character that distinguishes flies of this family is the wing venation and the hairiness of the wings and body. There are two *Psychodid* flies found in houses in India; one (probably *Psychoda*) has not a long proboscis, and when at rest carries its wings sloped at an angle over the abdomen, like the two sides of a gable roof (Plate II, fig. 5); this insect is harmless and not blood-sucking. (It breeds in the green algal masses that form in any spot where water drips.) The other (probably *Phlebotomus*) has in the female a projecting proboscis; the wings are, when at rest, held out from the body at an oblique angle (Plate II, fig. 4). This is the biting species. It measures about $\frac{1}{12}$ th

inch in length; the antennae are long and hairy, of many joints, the palpi are longer than the proboscis; the thorax is densely clothed with hairs; the legs are fairly long and slender.

Psychoda.

This fly will not be recognised without the aid either of a good lens or a microscope. The larva is slender, tapering slightly to the head, which is brown, the integument chitinised (Plate II, fig. 6); the mouth-parts are complex, functioning as brushes to sweep in food. The tracheal system is amphipeustic, with anterior and posterior functional spiracles. The posterior spiracles are on the apex of the tubular chitinised apical portion of the abdomen; at the edge of the end of the tube are four bunches of long setæ, on short processes, which enclose an air bubble or hold the spiracles at the surface of the water; the larvae thus exhibit the four processes characteristic of the *Psychoda* larva (Plate II, fig. 7). Larvae have been found in soil impregnated with water containing decaying animal matter. They have been reared abundantly, and are found in the same situations as the larva of *Ceratopogon* discussed above.

The pupa is found lying in the mud with two thoracic processes resting at the surface. These are connected to the main tracheæ and apparently are the source of air supply. These processes are not the open trumpets of the *Culicid* pupa, but are, so far as can be ascertained, closed; there are numerous round spots where the chitinous integument is either very thin or absent and apparently air is obtained through these.

Phlebotomus.

The fly is found not only in houses but under the bark of trees, under stones and in such sheltered situations. They have been found distended with blood in the field and have been seen sucking the blood of the common toad (*Bufo melanostictus*).

After the first heavy rain in June, they come into houses in abundance and bite freely, the first insertion of the proboscis not being much felt, but intense irritation being then produced. The males do not appear to bite but come into houses intent on mating.

In captivity flies laid eggs as figured (Plate II, figs. 1, 2), from thirty to sixty eggs being laid by one female in groups of up to six, on wet blotting paper in captivity. These eggs hatched, in eight days, to

slender white larvæ, which crawled about on wet blotting paper and fed on decaying vegetable matter; the paper was soaked with the decayed pulp of eucurbitaceous fruits, and the larva could be seen feeding on the particles. The larva is figured in Plate II, fig. 3. It is legless, with short fleshy processes on the lower surface which each bear a stout spine. On the side of each segment are two stout bristles. The hind end terminates in two black spots and two very long stiff hairs.

Up to the present these larvæ have not been found in the field and investigations have only reached this point. Purushottam has recently found this fly at Poona, and it is probably widespread in India; it has also been sent from Surat by F. M. Hodgson, Esq., Forest Officer, as being the common sand-fly there.

VI. SIMULIIDÆ.

Species of this genus, as far as it is known, occur only in the hills of India. Until recently one species had been recorded from the Himalayas under the name of the Potu fly (*Simulium indicum*), but since then another species has been found in the Khasi Hills. The Khasi Hill specimen differs in some respects from the Himalayan specimen, and it will be described more fully later. In the present paper it is sufficient to give the general characters.

Characters.—The flies are very small in size, measuring from about 2 m.m. to 4 m.m. in length. The colour is black or greyish-black.

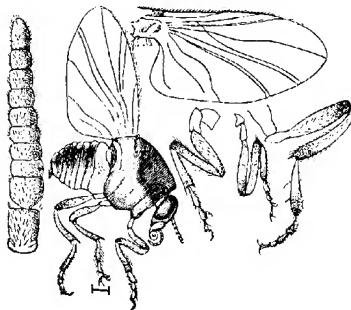


FIG. 8.
Simulium indicum. Beck,

The head is small and deflexed, with rather large eyes, antennæ short but straight and strong and with as many as ten joints; all joint are closely and broadly united, bare and slightly tapering.

The antennæ, when examined under a microscope, are seen to be clothed with minute soft hairs.

The palpi are projecting, composed of four segments, of which the first is generally short.

The thorax is raised above in a strongly convex manner that gives it a humped appearance, thick-set and short, the dorsum covered with very few short whitish silky hairs.

The abdomen is subglobular in shape, and generally black. The sides, the venter, and in some cases the middle of the dorsum clothed with short fine silvery hairs.

Legs strong and not elongated, femora broad and flat, tibiae without any terminal spines, tarsi black, the basal joint much more elongated.

Wings, broad and moderately long, hyaline, the 1st and 2nd longitudinal veins along the costa are stout and yellowish-brown. The others are slender and nearly hyaline, and when examined under a magnifying lens are found to be accompanied by a parallel line.

We figure the imago, antenna, wing, etc., of *Simulium indicum*; also the larva and pupa of the species recently found in the Khasi Hills. The following is a synopsis of Purushottam's report on the latter. Larvae were found in great abundance in the stream running down the

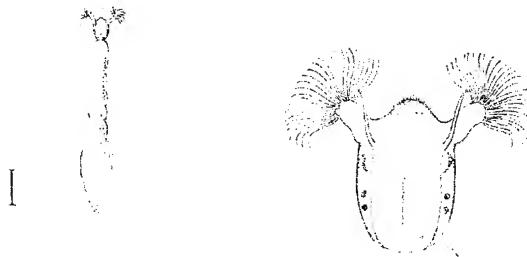


FIG. 9.
Larva of *Simulium*, and head (enlarged).

Khasi Hills at Umling, at an elevation of about 1,000 feet. Eggs were laid by the flies on the leaves of aquatic plants close to the surface.

the water; they hatch in four to five days. The larva on hatching descends into the water, and is found to be firmly attached to stones, leaves, etc., by means of the abundant hooks on the hind end on the single foot behind the head. The larva spins silken threads and clings to these threads, which pass from leaf to leaf in the stream. They are gregarious and are found most numerously in swiftly running parts of the stream shaded by trees and bushes.

The two prominent brush-like structures on the head serve to sweep in food, apparently small vegetable particles.

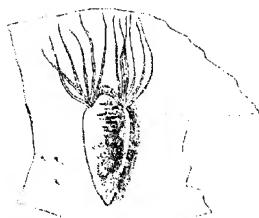


FIG. 10.
Simulium pupa.

The larva is whitish in colour; the length of its life has not been ascertained. Pupation takes place in the cocoon figured, which is made of silk and firmly fastened to the back of a leaf or to a stone in the water, the projecting filaments of the enclosed pupa functioning as gills. As the pupae die in stagnant water it has not as yet been possible to determine

the length of this period. When the fly emerges it comes to the surface of the water in a bubble of air and runs quickly along the surface to some object upon which it can rest and become dry.

VII. TABANIDÆ.

The known species of this group are large or very large, and in some cases almost the largest amongst the *Diptera*. The number of species is great, and the group is very widely distributed throughout India. The *Tabanidæ* are generally distinguished from others by the structure of the mouth-parts, and by the large size of the *Squamæ*. The group is divided into many genera, but only four genera are known in India. They are:—

1. <i>Tabanus</i>	·	·	·	}	<i>Tabaninx.</i>		
2. <i>Hematopota</i>	·	·					
3. <i>Pangonia</i>	·	·				}	<i>Pangoninx.</i>
4. <i>Chrysops</i>	·	·					

Key to the Genera.

Body large, ocelli absent, antennæ seven-jointed and as long as the head. Hind tarsi not spurred. *Tabanus*. (*Vide* fig. 8, Pl. III.)

Body moderate, ocelli absent, antennæ six-jointed, a little longer than the head. Hind tarsi not spurred. *Hæmatopota*. (*Vide* fig. 9, Pl. IV.)

Body large, ocelli present or absent, antennæ ten-jointed, and nearly as long as the head. Hind tarsi spurred. *Pangonia*.

Body moderate, ocelli always present, antennæ seven-jointed, and much longer than the head. Hind tarsi spurred. *Chrysops*. (*Vide* fig. 3, Pl. IV.)

I. *Tabanus*.

Characters.—Body large or very large, rather long, generally of a dark colour. Ocelli absent, palpi in male blunt as if truncate at the

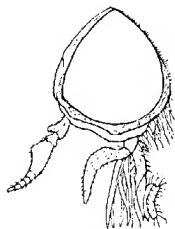


FIG. 11.
Head of *Tabanus*.

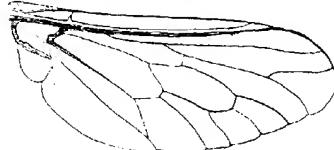


FIG. 12.
Wing of *Tabanus*.

apex, in the female pointed. Antennæ seven-jointed (or three-jointed with the third having five joints), first joint cylindrical, subclavate with the apex truncate, second joint cup-shaped and short, third compressed, excised at the tip generally in the male, and longest. Proboscis short, downwardly directed, fleshy when concealed in labium.

Wings clear, sub-hyaline, and held over the abdomen a little spread out. The nervures are widely distributed over the wing, the costal vein ending at the tip of the wing.

Number of Species.

The following species have been named by the British Museum:—

Name of Species.	Localities.
<i>Tabanus ditaeniatus.</i> Macq.	Nongpoh, Khasi Hills.
<i>Tabanus indicus.</i> Fabr.	Dadar, Bombay.
	Banda, United Provinces.
<i>Tabanus partitus.</i> Walk.	Bombay.
<i>Tabanus ? rubidus.</i> Wied.	Bassein, Bombay;
	Bombay.
<i>Tabanus rubidus.</i> Wied.	"
<i>Tabanus striatus.</i> Fabr.	Bassein, Bombay.
	Pusa, Bengal.
<i>Tabanus tenens.</i> Walk.	Parel and Bassein, Bombay.
	Banda, United Provinces.

The following species have been returned unnamed by the British Museum:—

	Localities.
1. <i>Tabanus Sp.</i>	Nongpoh,
2. " "	Shillong, Khasi Hills.
3. " "	Naduvatum, Nilgiris.
4. " "	Dumpep, Khasi Hills,
5. " "	Nongpoh, " "
6. " "	Parel and Bombay, Bombay
	Chapra, Bengal.
7. " "	Jalalpur, Surat.
8. " "	Nongpoh, Assam.
9. " "	Shillong,
10. " "	Naduvatum, Nilgiris.
11. " "	Parel, Bombay.
12. " "	Nongpoh, Assam.
13. " "	" "
14. " "	Parel, Bombay.
15. " "	Nongpoh, Assam.
16. " "	Shillong,
17. " "	" "
	Nongpoh,
	" "

Hæmatopota. (*Vide* fig. 9, Pl. III.)

Characters.—Slenderly built elongate flies with rather large head, which is broader than long; wings parallel, deflexed and spotted with black and brown. Antennæ six-jointed, or third joint with three cylindrical but long joints. First joint cylindrical, second short and cup-shaped; generally the whole antenna slightly exceeds the length of the head. Proboscis short, sometimes with an incision on the under side, and clothed with soft hairs below, tapering towards the apex and longer than the palpi.

Wings.—Dark, spotted often with brown and light colour, venation as in figure 14.

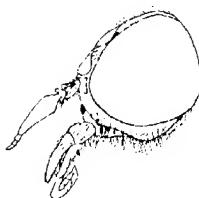


FIG. 13.
Head of *Hæmatopota*.



FIG. 14.
Wing of *Hæmatopota*.

Number of Species.

The following species have been returned unnamed by the British Museum:—

1.	<i>Hæmatopota</i> , Sp.	Igatpuri, Bombay.
2.	"	"
3.	"	Nongpoh, Assam.
4.	"	Chin Hills, Burma.
		Shillong, Assam.
		Nongpoh, Khasi Hills.
5.	"	Igatpuri, Bombay.
6.	"	Bombay.
7.	"	Shillong, Assam.
8.	"	Igatpuri, Bombay.
		" "

Pangonia.

Species of *Pangonia* occur chiefly in the hills, but have been very rarely met with in the plains of India. They are peculiar flies and can

be readily distinguished from allied genera, the proboscis being produced horizontally, elongated, wide at the base and tapering towards the apex, dagger-shaped.

Characters.—Head large, produced before the eyes, giving it a conical appearance. Antennae spear-shaped. Third joint complex with seven sub-joints.

Number of Species.

Pangonia Sp.	Mussoorie, United Provinces.
" "	Bombay.

The latter has lately been sent for identification by Colonel Bannermann, Plague Research Laboratory, Parel, Bombay. It is extremely doubtful if *Pangonia* is a blood-sucking fly.

Chrysops. (*Vide* fig. 3, Pl. IV.)

Characters.—Moderately built insects with rather large eyes, stout wings, with broad dark band extending across the wings, and held apart, never folded one over the other on the body. Body moderate, hairy and oblong.

Antennae very long, nearly twice the length of the head, three-jointed. First and second equal in length and clothed with short black hairs, third joint nearly equal to the second, complex with four sub-cylindrical joints. Proboscis much longer than the palpi.

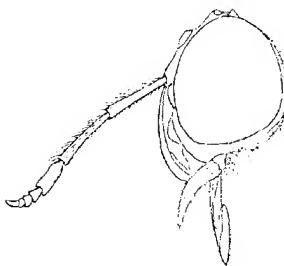


FIG. 15.
Head of *Chrysops*.



FIG. 16.
Wing of *Chrysops*.

Number of Species.

The following species have been named by the British Museum:—

1. <i>Chrysops dispar</i> Fabr.	Siillong, Assam. Nongpoh, Khasi Hills.
2. <i>Chrysops flavocinctus</i> Ricardo.	Nongpoh, Assam.
3. <i>Chrysops stimulans</i> Walk.	Pusa, Bengal.

Habits of the above Tabanids.

They are very blood-thirsty, and frequently attack cattle. They inflict a severe bite, so much so that a great flow of blood is occasioned from the wound. They feed at all times, but especially in the hot part of the day. When they see their victims passing, they dart upon them with great rapidity. Their presence can be known by their humming noise. The animals experiencing their severe prick try their best to get rid of these foes by means of licking, stamping, or by waving the tail. But the flies never leave their hosts until they are fully satisfied. In some instances, after the first sting, the animal does not feel any more pain, and consequently the fly enjoys its feed quietly. In others the animal experiences pain through the period of sucking, and this is made apparent by the uneasiness of the animal so long as the fly is on it. In others, again, besides the pain at the first insertion of the proboscis, a similar pain is experienced at the withdrawal. After satisfying themselves with the animal's blood, they do not hover about, but fly away. Their general resting place is a tree, though sometimes they are found resting on walls and other similar objects. Males are to be seen in such places as if they were waiting for the return of the females. The latter alone suck blood.

When they thrust their proboscis into the skin, a sudden burning sensation is experienced as if a red hot pin were thrust into it. Subsequent to this no irritation or pain is felt, and when the fly leaves its victims, blood is seen to ooze out from the wound. Certain species, though not all, are in the habit of attacking man as well as animals. Some flies have been noticed to inflict their sting on man, even entering conveyances which pass through jungles. The flight of *Tabanus* is very powerful, and they are able to keep pace with a running pony for a considerable distance.

Breeding places:— Woody jungle and forests appear most suitable spots for them to breed, as they were found to abound in great numbers

in such places. But they are often found in the plains of India, in low lands subject to flood, or in places where there are tanks, streams or rivers. On the Khasi Hills, flies occur in the month of April, and survive till July, *i.e.*, in the hottest part of the year: rain falls at this time though not as abundantly as during the rains. In the plains of India the period commences in August and lasts till September. After this period they begin to decrease in number and totally disappear after Christmas.

"Dans" is the common name for all the *Tabanids* except perhaps *Chrysops*.

Pangonia, as far as now known, is almost confined to the hills, and little is known of its habits.

Hæmatopota appears in numbers three weeks after the first heavy rainfall, and disappears about two months later: in the plains they are said to breed in low lands, mostly in rice lands. They always remain in one place, and attack man and animals which enter these limits. They may be found leaving this place when engaged in biting a moving animal.

People attribute their existence to the heavy rainfall that causes the grass to decay. From this decayed substance this sort of flies are said to appear: this is undoubtedly wrong, but their appearance and reappearance is dependent upon the heavy rainfall. In certain parts of Gujarat, where there are only rice lands, or low marshy lands, these flies appear in enormous numbers. The parts known to be full of such flies are "Bhal" near Kaira, and some places in the Ahmedabad district. Man as well as animals suffer a great deal from these flies, and animals are said to die there. It is also said by the inhabitants of such places that, among these flies, there are some species which kill animals by their poisonous bite. Horses if let loose to graze upon the open field in this season are likely to be affected by the disease known in vernacular as "Zerbaj" and in most cases succumb.

The following species are listed as Indian by Bigot (Catalogue of Oriental Diptera, Trans. Asiatic Soc., Bengal, LX, p. 264, 1891):—

Chrysops tigatus Walker, List. Dipt. Ins. Brit. Museum, Lond., i, 1848, p. 195.

Hab. Bengal.

Chrysops terminalis id., ibid., p. 195.

Hab. India.

Chrysops semicirculus id., *ibid.*, p. 196.
 Hab. India.

Chrysops stimulans id., Ins. Saunders. Dipt. London, i, 1856,
 p. 73.
 Hab. India.

Chrysops p. Uevidus Fabr., *Syst. Antl.*, p. 113.
 Hab. Tranquebar.

Chrysops dispar Fabr., *Entom. System. Suppl.*, p. 567.
 Hab. India.

Chrysops flaviventris id., *ibid.*, *Suppl.* i, 1846, p. 44.
 Hab. India.

Pangonia amboinensis Fabr., *Syst. Antl.*, p. 91.
 Hab. Amboina, Himalayas.

Pangonia longirostris, Walker, *List. Dipt. Ins. Brit. Museum*,
 London, 1854, pt. v, *Suppl.*, p. 139.
 Hab. India.

Pangonia rufa Macquart, *Dipt. Exot. Suppl.* pt. iv., Paris,
 1850, p. 18.
 Hab. Bombay.

Hematoptera cana Walker, *List. Dipt. Ins. Brit. Mus.*, London,
 pt. i, 1857, p. 112.
 Hab. Bengal.

Hematoptera roralis Fabr., *Syst. Antl.*, p. 107.
 Hab. Tranquebar, Madras Pr.

Tabanus auricinctus Macquart, *Dipt. Exot.*, pt. i, Paris, 1838,
 p. 130.
 Hab. Indian Archipelago.

Tabanus basalis id., *ibid.*, p. 126.
 Hab. India.

Tabanus consanguineus id., *Dipt. Exot.*, pt. i, 1838, p. 127.
 Hab. Malabar.

Tabanus sericeus id., *ibid.*, p. 128.
 Hab. India.

Tabanus rubicundus id., *ibid.*, *Suppl.*, 1846, p. 32.
 Hab. India.

Tabanus dorsolinea Wiedem., *Analect. Entomol.*, p. 22; *T. striatus?* Fabr.
 Hab. India.

Tabanus virgo id., *ibid.*, p. 22.
 Hab. India.

Tabanus orientalis id., *ibid.*, p. 21.
 Hab. India.

Tabanus rubidus id., *Dipt. Exot.*, i, p. 69.
 Hab. Bengal.

Tabanus rufiventris id., *ibid.*, p. 96.
 Hab. India.

Tabanus tenebrosus, Walker, *List Dipt. Ins. Brit. Mus.*, London, v, *Suppl.*, p. 242.
 Hab. Malabar.

Tabanus orientis id., *List. Dipt. Ins. Brit. Mus.*, pt. i, 1848, p. 152, and v, *Suppl.* i, 1854; *Addenda*, p. 328.
 Hab. Sikkim and Nepal.

Tabanus explicatus id., *ibid.* v, *Suppl.* i, 1854; *Addenda*, p. 328.
 Hab. Sikkim.

Tabanus auriflamma id., *ibid.*, p. 155.
 Hab. Sylhet, Assam.

Tabanus inscius id., *ibid.*, p. 161.
 Hab. Sylhet, Assam.

Tabanus internus id., *ibid.*, p. 164.
 Hab. Sylhet.

Tabanus albulus id., *Ins. Saunders, Dipt. i*, London, 1856, p. 46
 Hab. India.

Tabanus pyrrhus id., *ibid.*, p. 47.
 Hab. India.

Tabanus albinedius id., *ibid.*, p. 48.
 Hab. India.

Tabanus tenax id., *ibid.*, p. 49.
 Hab. India.

Tabanus hilaris id., *ibid.*, p. 49.
 Hab. India.

Tabanus crassus id., *ibid.*, p. 50.
 Hab. India.

Tabanus vagus id., *ibid.*, p. 50.
 Hab. India, Java.

Tabanus rubiginosus id., *ibid.*, p. 52.
 Hab. India.

Tabanus umbrinus, id., *ibid.*, 52.
 Hab. India.

Tabanus hirtus id., *ibid.*, p. 52.
 Hab. India.

Tabanus puello id., *ibid.*, p. 53.
 Hab. India.

Tabanus obconicus id., *ibid.*, p. 54.
 Hab. India.

Tabanus consocius id., *ibid.*, p. 56.
 Hab. India.

Tabanus perlinea id., *ibid.*, p. 56.
 Hab. India.

Tabanus nigropictus Macquart, *Dipt. Exot. Suppl.*, v, Paris, 1855, p. 24.
 Hab. India.

Tabanus abscondens Walker, *Trans. Ent. Soc. London*, v, 1860,
 p. 275.
 Hab. Burma.

Life-history.—A single species of *Tabanus* has been reared from

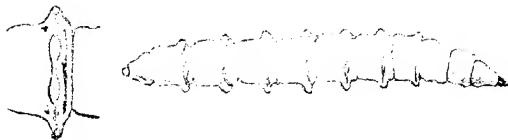


FIG. 17.
 Larva of *Tabanus*, $\times 2$. One segment $\times 4$.

larvae found in the shallow water at the edge of a pond. The larva is figured here; it is of a dull whitish colour, over one inch long

when full grown; the thoracic and the eight abdominal segments can be distinguished, the latter each having a number of soft tubercles set round the lateral and ventral portion of the anterior margin; these tubercles bear small hooks and are the only means of progression possessed by the larva. Air is obtained through the spiracles set at the apex of the abdomen on a retractile process. The larva lives in the mud at the edge of the pond and feeds upon small worms and other organisms. In captivity, it fed freely on small worms and pupated in April.

The pupa is found in the mud above the water; it is figured here. The fly emerged in May after a pupal period of about one month; there was a considerable variety in this respect in different pupæ, and probably the conditions were not natural.

Other larvæ believed to be those of *Tabanidae* have been found plentifully and also egg masses; we figure one egg mass of a *Tabanid* found in Pusa and also the egg mass of a European *Tabanid*. Eggs are apparently always laid on leaves, stems or other objects, very near to, or over water, so that the emerging larvæ can at once enter the water. Apparently the life-history occupies one year normally; the flies have each a definite season of about two months; they lay eggs, which hatch in a short time; the larva lives through the winter and pupates in the following hot weather and rains; it is highly probable that the larvæ are normally able to live in the dried up mud of pools until the onset of the rains fills the pools again and they can get food. It is noticeable in the drier parts of India the season for *Tabanids* is



FIG. 18.
Tabanus pupa $\times 2$.
One segment $\times 4$.

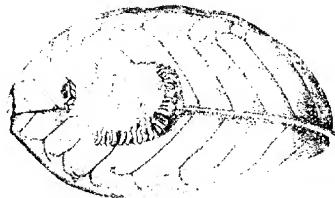


FIG. 19.
Egg mass of *Tabanid*.

late in the rains, while in Assam the flies are found earlier; the actual

yearly cycle of the flies' life will probably differ materially according to the dryness of the first six months of the year, and in the moister parts of India, where the larva can develop from March to June, there may be two broods yearly. In the drier parts the larvae must apparently wait until the rains fall in June to develop, and cannot emerge as flies until later in the year.



FIG. 20.
Egg mass of *Taeniamis quatuornotatus*. $\times 5$.
(From A. Lécaillon.)

VIII. MUSCIDÆ,

This family is very large, one of the largest among the *Diptera*. But the blood-sucking habit is restricted to only a very small number, and up to the present time only five genera have been discovered which are known to possess the habit of blood-sucking. They are :—

- (a) *Stomoxys*.
- (b) *Glossina* (the African Tse-tse flies).
- (c) *Lyperosia*.
- (d) *Hematobia*.
- (e) *Beccarimyia* (not known in India).

All these genera are allied to each other, and the blood-sucking habit is common to all: they are furnished with a rigid horny proboscis which is held in a horizontal position and may be recognised from other *Muscids* by this character. These genera breed in dung, save *Glossina*, which is viviparous.

Key to the Blood-Sucking Genera.

- Palpi very short and slender, nearly one-third the length of the proboscis. Arista feathered dorsally with eight long hairs *Stomoxys* (figs. 21, 22).
- Palpi as long as the proboscis, forming a complete sheath for the proboscis. Arista feathered dorsally with 25 long branched hairs *Glossina* (not Indian).
- Palpi as long as proboscis, forming a sheath for the latter. Arista feathered dorsally with 8 long pointed simple hairs; minute flies *Lyperosia* (figs. 23—26).
- Palpi club-shaped, and a little shorter than the proboscis, forming a partial sheath for the latter. Arista feathered dorsally with 10 pointed hairs, ventrally with four hairs *Haematobia* (figs. 27—28).
- Palpi a little shorter than the proboscis, but not club-shaped. Arista feathered as in *Haematobia* *Beccarimyia* (not Indian).

Stomoxys.

The genus is readily recognised by the short palpi and the arista. Although *S. calcitrans** has been known to inhabit India for some time, the number of species of *Stomoxys* that occur is wholly unknown. Purushottam has obtained four distinct species: they are distinguished by size and markings, and it is probable that further collecting will

* With Mr. Howlett's concurrence, I have omitted all detailed descriptions of species. At the present stage it is impossible to give *short* descriptions that will enable observers to *identify* their species; and to secure accuracy it is absolutely necessary that specimens should be compared with accurately identified specimens seen by Mr. Arribalzaga. (H. M. L.)

show that there are several species widely spread. Specimens of *S. calcitrans* are in the Pusa collection from Kamrup, the Khasi Hills, Calcutta, Rungpur, Pusa, Bombay, Thana, and Lahore; the fly is also reported from other localities, but it is not certain that these are *S. calcitrans*.

No. 8. *Stomoxys* B. is a smaller species, with unspotted abdomen, found in Calcutta on cattle.
 " 9. *Stomoxys* C. is a darker coloured species of the size of the last, found in Calcutta and the Khasi Hills.
 " 10. *Stomoxys* D. is the smallest species, with the thorax striped above: it has been found on cattle in Calcutta and Kamrup.

Stomoxys calcitrans.

This fly has much the appearance of the common house-flies of India, the straight sharp proboscis distinguishing it from them at once. It is figured in Plate IV, fig. 4, its wing and head in figures 21, 22. The male is distinct from the female in the greater proximity of the eyes at the vertex of the head; both sexes suck blood.

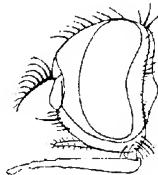


FIG. 21.
Stomoxys head.



FIG. 22.
Wing of *Stomoxys*.

Habits.—These insects rest at night on weeds, shrubs and grasses growing on the sides of roads and in the neighbourhood of cattle-sheds. Early in the morning, just about sunrise, they become active and begin to fly in search of food. During these hours especially, being very hungry, they grow blood-thirsty as the day advances, and furiously attack man as well as animals passing by. They are very persistent in their attack and do not cease till they are satisfied, but if the victim is nimble, they are often disturbed and are compelled to leave it and fall upon another.

Thus they go from one animal to another until their appetites are satisfied. They generally prefer the legs, although they are sometimes found on other parts of the bodies of their victims. They continue sucking for a minute or two and then are generally satisfied, provided they are not disturbed. When fully fed they have a peculiar appearance, and may be easily distinguished even by the inexperienced, as the abdomen bulges out in an extraordinary manner with the amount of the blood they have sucked which gives it a bright red appearance. Unlike many other flies, they do not annoy animals during the hottest hours of the day, but the majority of them take refuge in shrubs, weeds, etc. The bite produces a sudden burning sensation a little more painful than that of the mosquitoes; and if allowed to bite for a time the blood not unfrequently oozes out from the wound. When at rest they are found coupling, the most favourable time being the hottest part of the day.

A fly that is fully satisfied does not require food for at least three or four hours: this has been ascertained by experiments carried out at the Plague Research Laboratory, Parel, Bombay, during the year 1905. Again at sunset they are found attacking animals, but not so eagerly as in the morning. The pregnant female chooses this time to lay her eggs, which time, so far as has been seen, is most suitable for them to bury their eggs.

Time of appearance.—They are most abundant in August and September, but are found throughout the year in the plains except during the colder weeks.

Egg-laying.—This fly is found depositing its eggs in places which become moist with animal droppings. It also haunts places rendered filthy by the constant urination of man and animals. The egg-laden female goes there in search of seclusion, and begins to lay her eggs. It moves from one place to another during this process. The number of eggs laid by one female is from 40 to 50, and varies according to climatic conditions and the individual mother-fly. Eggs are laid in a loose bundle of about 10.

Eggs.—The newly deposited egg is nearly 1½ m.m. in length, milky white in colour, and in many respects resembling that of the common house-fly. It is sub-cylindrical in shape, slightly tapering at the posterior end, and somewhat blunt at the anterior. A longitudinal groove is found on the flat ventral surface. This groove is widened towards the anterior end, whence the larva effects its exit. Eggs, after

a period of some twelve hours, turn yellowish-white. After preserving this condition for a period of about 7 to 8 hours they are hatched out into larvæ.

Larvæ.—The newly hatched larvæ are maggots measuring $1\frac{1}{2}$ m.m. in length on the first day, 5 m.m. on the fourth day, 8 m.m. on the eighth day. They are white in colour. The skin is so transparent that the internal structures are seen through it. The epidermis is without hairs. The segments are distinct and eleven in number. In shape the larva is cylindrical and gradually tapering to a point towards the head, and very broadly rounded towards the tail. The tail bears a pair of large dark-brown stigmata. The head is very small and retractile, with two black mandibles.

These maggots, on hatching, descend into the decaying vegetable matter and feed upon dirt, which gives them a dark appearance. The full grown larva measures 10 m.m. in length, and when full fed shrinks in length, becoming broader and turning into the oval brown pupa. The larval stage lasts from about 11 to 12 days in the hot season.

This species was also extensively reared from decaying tobacco leaves brought from Rungpur.

Pupa.—The pupa (puparium) is seed-like in appearance, with a black cap on the front end, and measures 5 m.m. in length; its diameter is nearly 2 m.m. It is incapable of locomotion, and changes colour from whitish-yellow to red, brownish-red, and finally dark-brown. The segments are clearly marked out by a narrow dark stria. This stage lasts for about a week.

Summary of Life-cycle.—Egg period lasts for about 20 hours. Larval period lasts for about 12 days. Pupal period lasts for about 7 days. The whole cycle is completed in nearly three weeks, excluding the imago stage.

Enemies.—The larva of *Stomoxys calcitrans* is the host of a *Hymenopterous* parasite, reared by Purushottam from larvæ found at Nongpoh and Umling: it does not appear to be a check of very great importance as it has been reared only from a very small number of larvæ out of a large total number. The flies are the prey of a fossorial wasp, *Oxybelus squamosus*, Sm., which has been seen to paralyse them and carry them off, presumably to store for its larva. (This is the habit of *Oxybelus* to carry off flies to stock the larval cells.) Spiders have also been seen to prey upon *Stomoxys*.

Lyperosia.

The characters that distinguish the genus are shown in figures 23—26.

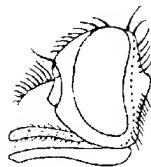


FIG. 23.
Head of *Lyperosia exigua*.



FIG. 25.
Wing of *Lyperosia exigua*.

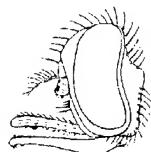


FIG. 24.
Head of *Lyperosia minuta*.



FIG. 26.
Wing of *Lyperosia minuta*.

Three species have been found in India up to the present.

Lyperosia exigua, de Meij. This was identified by Mr. E. E. Austen. It occurs also in Java. In India it has been found to occur in Thana (Bombay), Rungpur, Belgachia (Calcutta), Umling and Nongpoh (Assam), Baroma (Kamrup). (Plate III, figs. 5, 6.)

Lyperosia minuta, Bezz, was also identified by Mr. Austen, who states that it occurs in Somaliland, West Africa, and Ceylon. In India, it has been found in Rungpur, Belgachia, and Umling (Plate III, fig. 7). No. 5 *Lyperosia* C. is a smaller fly than the above, that has been reared from cowdung in Belgachia and found biting cattle there.

Lyperosia exigua.

Habits.—The blood-sucking habit is common in both sexes. They are generally seen or found on animals during the day. They select

the flanks or neck of cattle for their food and seldom choose the legs. They prefer these parts, as they are beyond the reach of the animal's tongue or tail, and hence they can feed without disturbance. They are very active in flight and cannot be easily caught with the hands. Copulation takes place on the body of the animals while the female is feeding. They do not like heat of any kind. Cattle exposed to the direct rays of the sun are not so generally attacked as those kept in the shade. They are not particular as to when they should take their food, but are seen feeding all through the day. Even at night I have observed them feeding on the cattle up to 10 P.M. They appear in a great number after a shower of rain, and are seen attacking cattle furiously. Up to the present spiders and lizards are its known enemies.

Occasionally this fly attacks human beings, and chooses the head for biting. It is only in the case of its being disturbed, and in the absence of cattle, that this fly has been seen attacking human beings. Its bite causes a burning sensation with a slight irritation, but the bitten portion does not get inflamed.

It makes scarcely any noise when flying, but a slight humming can be heard when it flies close to the ear. The following animals are observed to be attacked by these flies:—Horses, cattle, buffaloes, goats, and occasionally guinea-pigs.

Egg-laying.—They deposit their eggs in the fresh dung of cattle. If the dung has lain exposed even for a short time, they will not choose it for egg-laying. The mode of oviposition is as adopted in most flies, *viz.*, by protruding the ovipositor and inserting it below the surface of the dung, thus making a puncture, in which one egg or sometimes more are deposited.

It is interesting to watch these flies when the cattle drop their excreta. The instant the excreta reaches the ground these flies will hasten to it and deposit their eggs; thus giving the excreta no time to get a hard external layer. The number of eggs laid by each individual is about 20. All these eggs are not laid at one sitting, but a portion of them are retained to be deposited at some future time when an opportunity occurs. They are capable of retaining the ova in their bodies for about one hour.

Eggs.—Light pinkish-brown (when fresh), measuring about 1 m.m. in length; in shape they are cylindrical with the ends tapering, and with the usual groove on the ventral surface. They hatch out in 10 to 11

hours, but if at all exposed to the air they soon die. (*Vide* figs. 1, 2, Pl. III.)

Larvæ.—Newly-hatched larvæ are maggots measuring 1 m.m. in length. They are white, transparent, and cylindrical in shape, tapering anteriorly. The head is very small, almost reduced to a point, and possesses a pair of black mandibles. As the larvæ increase in size, they darken in colour owing to the food they eat. They develop inside the dung, and when full grown they measure 6 to 7 m.m. in length. The larvæ remain for seven days in this stage. Before pupation the larvæ begin to shorten in length, but become fatter. (*Vide* fig. 3, Pl. III.)

Pupa.—Immediately the larvæ pupate, the pupa assumes a light-brown colour, after three hours it becomes reddish-brown, and finally before the adult fly emerges the pupa is dark-brown. The pupa has ten segments; each segment is marked out by a shallow constriction. (*Vide* fig. 4, Pl. III.) There are very conspicuous black margins on both the ends. The pupal stage lasts from 4 to 5 days.

Summary of Life-cycle.—Egg stage 12 hours, larval stage 7 days, pupal stage 4 to 5 days. The whole life-cycle, excluding the adult stage, which is not yet fully known, occupies nearly two weeks in the hot season.

Lyperosia minuta.

The habits of this fly are the same as those of the preceding. They bite cattle and horses, but are not yet definitely known to bite man. In the laboratory they suck blood of guinea-pigs. They have not been reared but will probably be found to breed in dung.

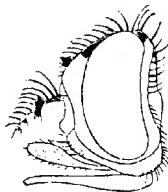


FIG. 27.
Head of *Haematobia*.

Hæmatobia.

A small number of specimens have been collected on cattle and found to suck blood.

No. 4. *Hæmatobia* A, found at Nongpoh.

No. 11. *Hæmatobia* B, found at Umling.

No. 12. *Hæmatobia* C, found at Baroma.

A single species of fly with the arista feathered on both sides but the palpi short and slender has also been found at Nongpoh on cattle. The generic position of this species is uncertain.



FIG. 28.
Wing of *Hæmatobia*.

Hæmatobia has not yet been reared; the known species elsewhere breed in dung, and it is probable that the Indian species will be found to have the same habit. The characters are shown in figs. 27, 28.

IX. HIPPOBOSCIDÆ.

(*Vide* fig. 2, Pl. IV.)

Characters.—They are flat, rather large flies, with a small head, broad thorax and moderate abdomen, with stout and very ample wings.

Proboscis (Fig. 29).—Of peculiar form, consisting of an exsertile tube between two membranous processes, which are shining black in

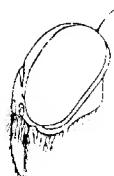


FIG. 29.
Head of *Hippobosca*.



FIG. 30.
Wing of *Hippobosca*.

colour and clothed with a few hairs. Posterior portion of the head produced, as to form collar between the thorax and the head.

Habits.—These flies have all similar habits, being parasitic on all kinds of animals. It is the common fly which one is accustomed to see flying round cattle. They fly but very little, as they are very persistent on their hosts, and will not leave them though they may be driven away for a time. They are swift runners, and in running they often go sideways. The flies of this genus which are parasites on cattle and horses live chiefly between the thighs, on the neck and under the tail. Unlike other flies they are hardly ever seen wandering about, and even during the night they do not leave their hosts. The flies which are most active during the day are those most easily secured at light, as they seem dazzled by it. The females of all these flies are viviparous, *i.e.*, they produce a single full-grown larva at a birth. The larva in its early stage is nourished by the secretion of special glands of its mother. The place of their oviposition is not as yet fully known, but on several occasions I have met with these larvæ on such places as cemented floors of unfrequented rooms, and ledges of the windows and the walls. Loose soil, faeces of animals, and filthy places may be considered not congenial for their oviposition, as there are no traces of pupæ found out in the searches conducted on many occasions in the stables. Females are apt to deposit the young of any stage in captivity: this makes the study of all stages of the young easy for the student.

Life History of *Hippobosca maculata*, Leach.—The puparium is oval, almost egg-shaped, the skin reticulate, smooth to the eye. At one pole is a circular black mark, the rest being, at first, white. The skin is at first semi-transparent; in the course of a few hours it darkens through orange to brown and to deep black all over. It is then a hard black seed-like object. (Fig. 1, Plate IV.)

The larva is a similar ovate body, at one pole a pulsating tipped projection, resembling a three-lipped mouth, which pulsates evenly, being withdrawn and exserted rhythmically as if it was a suctional apparatus drawing in liquid from a teat to which the lips were fixed. At the opposite pole is a number of fine stigmata, connected to tracheal branches which ramify from long tracheæ. There are two main tracheæ, each three-branched, not connected. These are all black. After some hours the skin covering this pole darkened, forming the dark caps seen in the previous specimen. There are two main tracheæ, white and

shining, which pass from the dark pole towards the pulsating lips: they give off branches and are apparently the main tracheal trunks connecting with the two main dark branches to which the spiracles are attached. These longitudinal trunks do not divide the circumference of the insect, but are both visible in one-half of the insect.

After having remained 25 to 27 days as the pupa, the perfect fly emerges from it. The exact number of pupæ that are laid by a single individual is not known: but the females undoubtedly do not die after a single birth, but survive to produce future progeny.

Number of Species.—A large collection of these flies has been made, from specimens sent in by the Officers of the Civil Veterinary Department. Dr. Speiser has identified them and finds two species:—

(1) *Hippobosca capensis*, Olf.—(*H. canina*, Rond, *H. francilloni*, Leach.) The Dog Fly. Sent in from Bombay, Igatpuri, Gujranwala, Benares, Gorakhpur, Cawnpore, Meerut, Sitapur, Azamgarh, Jaunpur, Dehra Dun, Ghazipur, Garhwal, Fyzabad, Agra, Lucknow, and Nongpoh. It is common at Pusa and is probably the Dog Fly of all India.

(2) *Hippobosca maculata*, Leach.—(*H. Calopsis*, Big., *H. sudanica*, Big.) The Cattle Fly. Found on cattle at Bombay, Nadiad, Banda, Lucknow, Naini Tal, Saharanpur, Azamgarh, Farukhabad, Gorakhpur, Sitapur, Hardoi, Harpur, Nilgiri Hills, Pusa, Calcutta, Pithapuram, Umling, Nongpoh, Baroma.

Hippobosca maculata, Leach, var. *siriae*, Big. (var. *egyptiaca*, Macq.), was found on cattle in Bombay, Lahore, Hardoi, Azamgarh, Etah, and Calcutta.

XI. CONCLUSION.

The following sums up the present position of affairs as regards biting flies in India.—

Family	Species.	Remarks.
<i>Chironomidae</i>	<i>Ceratopogon</i>	Several species habitually bite man.
<i>Culicidae</i>	.....	Many species bite man.
<i>Psychodidae</i>	<i>Phlebotomus</i>	Bites man.
<i>Simuliidae</i>	<i>Simulium indicum</i> , Besch	Bites man.
<i>Tabanidae</i>	<i>Tabanus</i> . Many species <i>Chrysops</i> . Three species <i>Hæmatopota</i> . Eight species	Bite cattle, horses, etc.; man occasionally bitten.

Family	Species.	Remarks.
<i>Muscidae</i>	<i>Stomoxys calcitrans</i>	Bites domestic animals and man.
	<i>Stomoxys</i> . Other species	Bite cattle.
	<i>Lyperosia exigua</i> , de Meij.	Bites cattle, horses, and man.
	<i>Lyperosia minuta</i> , Bezzi	Bites cattle and horses.
	<i>Lyperosia</i> C.	Bites cattle.
	<i>Homatobia</i> . Several species	Bite cattle.
<i>Hippoboscidae</i>	<i>Hippobosca Capensis</i>	Bites dogs.
	<i>Hippobosca maculata</i>	Bites cattle.

In the first place, there is no record yet of *Glossina*, the Tse-Tse fly of Africa, nor is there at present any reason to believe that it occurs in India; in fact, the work of the last two years goes to confirm the belief that this genus will not be found in India. In the next place, there are a small and definite number of flies which are worth attention as possible communicators of disease from man to man. Excluding the mosquitoes, we would look upon the sand-flies *Ceratopogon* and *Phlebotomus* with suspicion, and also on *Stomoxys* and *Lyperosia*. These breed quickly, they are not confined to one short annual season, they occur in towns and inhabited places.

Simulium indicum, Beach, is a hill species: the *Tabanidae* are forest insects biting cattle but only occurring as flies for part of the year; the *Hippoboscidae* practically only bite animals. The significance, then, of these biting flies differs as we regard them from the point of view of insects disseminating cattle-diseases or diseases of man.

Our object in this paper is to describe the progress made with a view to securing co-operation and recording a step in advance. We can breed some of the species likely to affect man in sufficient quantity to supply the needs of an investigator, and this is one of the first requirements in such an inquiry. But progress must be intensely slow if the co-operation of observers in all parts of India cannot be secured, and I would reiterate the hope that anyone interested will communicate with Mr. Howlett at Pusa and draw freely on him for assistance. Further, I will be glad to at once arrange, so far as is possible, for breeding supplies of any of the flies, except *Tabanids* and some *Muscids*) mentioned herein for the use of investigators who wish to test their behaviour in relation to the diseases of man or cattle; it is probable that by the time this is in print Purushottam will have solved the problem of *Phlebotomus* and be able to rear it readily; the others can be reared more easily.

XI. COLLECTING.

The greatest care must be taken in collecting flies that they are never injured or wetted. For collecting flies on cattle, it is best to have a supply of corked tubes of the same size, containing each a twisted piece of tissue paper that has been dipped in benzene. The cork may be taken out when the fly is seen to settle, the tube rapidly put over the fly, which is at once killed by the fumes of benzene; the fly is then taken out of the tube and pinned as soon as possible as the moisture from its body will soon settle on the glass and so wet the fly. Flies can also be collected in tubes, brought home alive, and then killed.

The tubes may be supplemented by the use of pill-boxes of card-board with glass bottoms (glass tops are of no use), in which to bring home live flies. To protect them from the debilitating effect of the rains they should have a thin coat of paint, enamel, or shellac dissolved in rectified spirit. Though less safe to use than benzene, a cyanide bottle is often very convenient for killing. A wide-mouthed bottle, if possible with a screw top, contains one or two small lumps of cyanide of potassium (a deadly poison) screwed up in dry paper and more tissue paper, loosely crinkled, is arranged so as to prevent the flies, or the bits of cyanide, from rolling about. Flies should never be left in cyanide longer than can be helped, as they may get damp and discoloured from touching the cyanide and also become stiff and awkward to set. The cyanide should be exposed to the air as little as possible. In emergency, flies in tubes or pill-boxes may be killed by tobacco-smoke, to which they soon succumb. Flies on windows may be imprisoned alive by putting a pill-box over them, slipping a piece of wafer along the glass under the pill-box so as to allow of the latter being removed, and then putting on the lid. A worried fly almost always goes towards the light.

For ordinary collecting a net is required; the fly is captured in the net with a strong sweep, the end of the net is at once twisted over the rim and the fly shaken down to the bottom. The fly is then captured in a fold of the net, a tube inserted and brought over the fly and so removed.

No directions can here be given for actually finding flies of the required kind as they must each be looked for in their usual haunts.

Flies are pinned on cork slips if they are small; a small pin (No. 20)

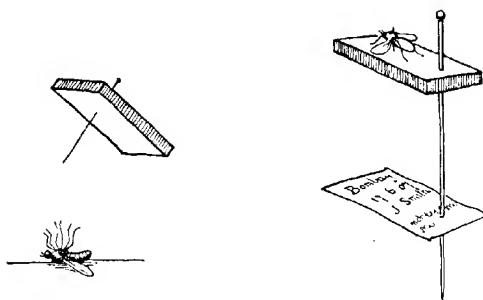


FIG. 31.
How to pin a Fly.

is driven through the thorax from above, and the fly then pinned on to the cork slip; a thick pin is then pushed through the cork at one end and the fly or the cork pinned into the store-box. If the fly is large, a long thin pin (No. 2) may be used to pin the fly directly in the store-box without any cork slip.

Cork slips are rectangular, of $\frac{3}{16}$ inch thick cork sheeting, with thin white paper on one side.

In manipulating slender entomological pins, forceps are practically indispensable, and wherever possible the pin should be held near the

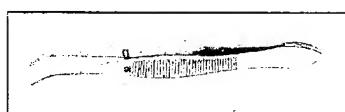


FIG. 32.

point, not near the head, when being pushed into cork, and when flies are not on slips, but simply on the pin (*i.e.*, in the case of large flies), the point should protrude a long way beneath the body of the fly so as to allow a good length of pin to give a hold for the forceps (fig. 32).

It is often not easy to pin very small flies straight through the back, and in such cases it will be found an advantage to lay the fly on its back; then take a cork slip and with a pair of pin-forceps thrust through the slip a thin pin in the reverse way (*i.e.*, with the head of the pin on the unpapered side of the slip). Then take the slip and carefully push in the point of the pin between the roots of the fly's legs until it just comes through at the back. The pin may then be gently pulled down with forceps until the fly's legs touch the cork slip and can be arranged to the best advantage. (See fig. 31.)

Small flies may also be pinned lying on their sides. In such, and indeed in all, cases it should be remembered that it is important to be able to get a good view of the legs, which should not be allowed to lie bent up close to the body, but should be gently persuaded into a suitable position with a needle or long pin. The cork slips are recommended for all flies smaller than a blue-bottle. The size of the slip should be such that no portion of the insect overlaps the edge of the slip. When an insect is pinned to the slip it is a good plan to snip off the head-end of the pin with scissors, so as to leave only a little piece sticking up from the thorax. This makes the fly easier to examine and less liable to injury.

Every specimen must be labelled with the date, exact locality (village or town, district, and province), and the name of the collector, with any remarks such as "on cow," "in house;" if caught in copulation they are marked "male in cop," and "female in cop."

The naphthaline, though useful and easily obtained, is not altogether satisfactory. A piece of sponge dipped in *pure* carbolic acid is good, and we are indebted to Dr. Graham of West Africa for a method which he has found extremely effective as a preservation against both mould and insects. This is to swab out the whole store-box with a piece of cotton soaked in "medical" (beech) creosote. We have not yet been able to give this method a trial, but it appears to be a valuable one. It is being tried on a large scale at Pusa, and we will be glad to give any inquirer the result of our experience.

As mould attacks flies at once in damp places, the store-box containing flies should contain enough naphthaline properly secured to be perceptible and the box and specimens must be kept dry.

In distinguishing males from females, when the flies are caught separately, the test most generally useful is the distance between the

eyes along the top of the head. In most flies the eyes in the male are distinctly nearer together than in the female. Very often they touch in the male and are well separated in the other sex; this distinction does not hold in the *Culicidae* and *Chironomidae*, but in them the antennæ, feathery and plumose in the males but otherwise in the females, afford a means of recognition of sexual difference. When there is still a doubt, the shape of the insect's tail-end will often clear it up. In the female sex this is frequently rather pointed, often with an indication of an ovipositor, while the males have as a rule a blunter abdomen and frequently show a pair of clasping organs.

Specimens of biting flies are wanted from all parts of India, and to anyone willing to collect, a copy of this bulletin with a postal store-box, pins and cork slips, tubes and a net will be sent, on condition that the flies are sent as soon as possible to Pusa for study and that duplicates may be retained for preservation. The same applies to ticks, lice, fleas, etc. Knowledge about biting insects is slowly growing, and it will grow more rapidly if residents in any part of India will send specimens of insects that bite them or cattle. It will probably be found that sand-flies are too small for pinning by any but a very experienced setter, and in this case the flies are best kept in small dry corked tubes, the corks of which have been dipped in naphthaline dissolved in benzene. The minutest flies keep well in this way if carefully dried before putting into tubes.

EXPLANATION OF PLATES.

PLATE I.—

FIG. 1.—Larva of *Ceratopogon*, magnification 15.
" 2.—Lateral view of hind end of larva of *Ceratopogon*, much more magnified.
" 3.—Pupa of *Ceratopogon*, ventral view.
" 4.—Tracheal trumpet of pupa of *Ceratopogon*, much more magnified.
" 5.—Male *Ceratopogon*, magnification 25.
" 6.—Head of female *Ceratopogon*.
" 7.—Lateral view of hind end of male *Ceratopogon*, much magnified.

PLATE II.—

FIG. 1.—*Phlebotomus* eggs as laid, magnification 15.
" 2.—A single egg much magnified.
" 3.—Larva of *Phlebotomus* in first stage, magnification 70.
" 4.—*Phlebotomus*.
" 5.—*Psychoda* A.
" 6.—Larva of *Psychoda* B.
" 7.—*Periconta canescens*. Last abdominal segment, end view, showing two pairs of anal processes, magnification 50. (After Miall and Walker, Trans. Ent. Soc., London, 1895, Pl. IV.)

PLATE III.—

FIG. 1.—Egg of *Lyperosia exigua*, de Meij. $\times 15$.
" 2.—" of " " " " $\times 6$.
" 3.—Larva of " " " " $\times 10$.
" 4.—Pupa of " " " " $\times 10$.
" 5.—*Lyperosia exigua*, de Meij.
" 6.—" " " " "
" 7.—*Lyperosia minuta*, Bezz.
" 8.—*Tabanus*.
" 9.—*Hemiallofola*.

PLATE IV.—

FIG. 1.—Pupa of *Hippobosca maculata*, Leach.
" 2.—*Hippobosca maculata*, Leach.
" 3.—*Chrysops dispar*, Fabr.
" 4.—*Stomoxys calcitrans*.
" 5.—*Humatobia*.

PLATE I.

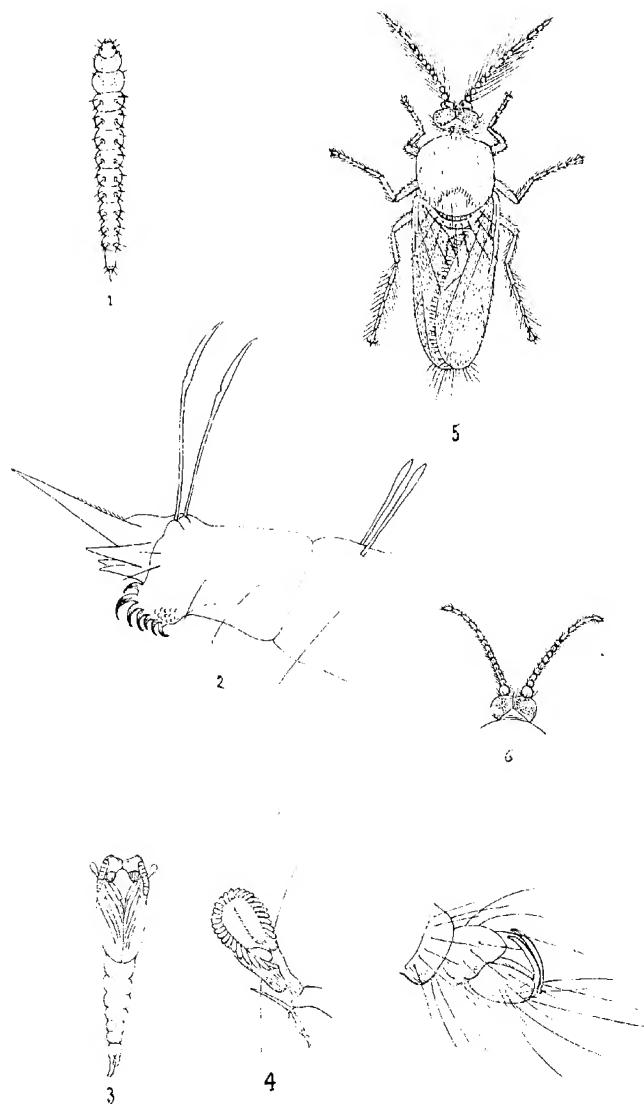


PLATE II.

PLAT. No. 7.

